INTERIM GEOLOGIC MAP OF THE SNOW BASIN QUADRANGLE AND PART OF THE HUNTSVILLE QUADRANGLE, DAVIS, MORGAN, AND WEBER COUNTIES, UTAH

by

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This geologic map was funded by the Utah Geological Survey and U.S. Geological Survey, National Cooperative Geologic Mapping Program through U.S. Geological Survey STATEMAP award number 00HQAG109. The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Government.

OPEN-FILE REPORT 536
UTAH GEOLOGICAL SURVEY
a division of
Utah Department of Natural Resources
2008

SUMMARY

The Snow Basin quadrangle is located east of Ogden, Utah, on the divide between Ogden Valley to the north and Morgan Valley to the south (figure 1). The major geographic features in and near the quadrangle are these valleys and the northern Wasatch Range to the west, as well as the Weber River in Morgan Valley, the Ogden River in Ogden Valley, and Weber and Ogden Canyons that these rivers cut into the Wasatch Range. Durst Mountain is southeast of the quadrangle and an unnamed group of flat-topped mountains are northeast of the quadrangle. The valleys formed due to Cenozoic extensional faulting along at least one margin of each valley and are filled with probable Oligocene Norwood Formation tuffaceous, lacustrine and fluvial sedimentary rocks. The Precambrian (early Proterozoic) Farmington Canyon crystalline rock complex and unconformably overlying Paleozoic (Cambrian into Mississippian) marine sedimentary strata are exposed in the Wasatch Range on the west margin of the quadrangle. More information on these rocks is available in Yonkee and Lowe (2004), who geologically mapped the Ogden 7.5' quadrangle, directly west of the Snow Basin quadrangle (see also Bryant, 1988). A southern edge of the Willard thrust sheet, a Cretaceous structural feature containing late Proterozoic meta-sedimentary and Paleozoic sedimentary strata, is exposed in the quadrangle and to the north and east in the North Ogden, Huntsville, Browns Hole, and Durst Mountain quadrangles (Crittenden, 1972; Sorensen and Crittenden, 1972, 1979; Crittenden and Sorensen, 1985; Coogan and King, 2006). The thrust sheet is likely buried under several thousand feet of Cenozoic valley fill in the northern part of the Snow Basin quadrangle. The Cretaceous Ogden roof thrust is exposed within the Maxfield Limestone on the west edge of the quadrangle. To the east the thrust is covered by Quaternary (Pleistocene) glacial deposits and Cenozoic valley fill; it is exposed to the southeast on Durst Mountain (figure 1). Imbricate thrust faults off the Ogden roof thrust are likely present in Cambrian rocks beneath Quaternary (Pleistocene) glacial deposits on the west margin of the map area. The Paleozoic rocks have been faulted, folded, and thinned during movement on the Willard and Ogden thrust faults. The Precambrian and Paleozoic rocks and Cretaceous thrust sheets are unconformably overlain by the Cenozoic (Eocene) Wasatch Formation. The Norwood Formation overlies the Wasatch Formation in the quadrangle and to the east intertongues with and is overlain by an unnamed Oligocene(?) conglomerate. These conglomeratic rocks are unconformably overlain by conglomeratic Miocene and/or Pliocene strata (see Coogan and King, 2006 for details). Remnants of Pliocene and/or Pleistocene alluvial deposits are present in the quadrangle and farther south on both sides of Morgan Valley in the Peterson and Morgan quadrangles. Quaternary (middle and upper Pleistocene) glacial deposits cover bedrock in the western part of the Snow Basin quadrangle, and cirques are well developed on the crest of the Wasatch Range in the quadrangle and just to the west in the Ogden 7.5' quadrangle. Uppermost Pleistocene lacustrine, deltaic, and alluvial deposits related to Lake Bonneville are present in both Ogden and Morgan Valleys. The Bonneville shoreline is visible in both valleys. The Provo shoreline is concealed by Pineview Reservoir in Ogden Valley, is mostly eroded in Ogden Canyon and near Mountain Green in Morgan Valley, and is visible in

Weber Canyon in the Snow Basin quadrangle. Also note that no landslides are mapped that are younger than the September 1986 aerial photographs used to create the map and that fill along Utah State Highway 167 (Trapper Loop road) was not mapped because it post-dates these photographs.

The most complete geologic maps of the Snow Basin quadrangle prior to this study were by Bryant (1984, also in 1988), who focused on the Precambrian Farmington Canyon Complex, and by Rogers (1986), who mostly focused on landslides (using Bryant's map as a base) and did geotechnical studies. Prior to this work, small parts of the quadrangle were mapped in detail by Coody (1957), Eriksson (1960), and Pavlis (1979). For this study, King mapped most of the quadrangle, and Yonkee and Coogan contributed mapping of Paleozoic outcrops; any modifications to their contributions are the responsibility of King. King modified some of the Precambrian from Bryant and mostly photogeologically matched the Precambrian and Paleozoic contacts on the Snow Basin map with the Ogden 7.5' geologic map of Yonkee and Lowe (2004); see paragraph below for details on matching. Attitudes are lacking in Precambrian rocks in the Snow Basin quadrangle because they were not field checked; attitudes shown by Bryant (1988) are not included on this map because, in the Ogden 7.5' quadrangle, his attitudes differ from those shown by Yonkee and Lowe (2004). Roger's (1986) mapping differs from the map in this report, in particular his mapping of Tertiary geology (his Tw, Tn, and Th), but, given his emphasis on landslide mapping, should be consulted for geologic hazard assessment.

The rocks on the south side of Ogden Canyon and Pineview Reservoir are structurally complicated (see for example Pavlis, 1979) and are concealed by vegetation and slope debris; the geology we see is not that shown on the geologic map of the adjacent Huntsville quadrangle (see Sorensen and Crittenden, 1979). Therefore, we chose to extend our map north of the Snow Basin quadrangle to the Ogden River and Pineview Reservoir, leaving a minor mismatch across the water rather than a striking mismatch at the quadrangle boundary.

The mismatch of our map to the Ogden 7.5' geologic map of Yonkee and Lowe (2004) is due to gradational contacts in Precambrian rocks, the greater precision produced by the stereoplotter used to create the Snow Basin map, and differences between authors. The mismatch is most significant in the northwest part of the map area, where lower Paleozoic beds strike northwest-southeast east of the ridge crest rather than the east-northeast shown on the Ogden 7.5' quadrangle. The mismatch of Quaternary deposits shows typical differences between different mappers; for example, one mapper might consider the Quaternary too thin to show, while another thinks the same thickness is significant and needs to be mapped.

DESCRIPTION OF MAP UNITS

All years noted in Quaternary units (Q_) are Carbon-14 years unless otherwise noted.

QUATERNARY

Alluvial Deposits

Qal, Qal2

Stream alluvium and flood-plain deposits (Holocene) - Sand, silt, clay, and gravel in channels, flood plains, and terraces less than 10 feet (3 m) above the Ogden and Weber Rivers and larger creeks; locally includes muddy, organic overbank and oxbow lake deposits; composition depends on source area; 0 to 20 feet (0-6 m) thick; suffix 2 indicates slightly older deposits in Ogden Valley that are 5 to 10 feet (1-3 m) above present drainages and low terraces about 10 feet (3 m) above the Weber River.

Qaty

Stream-terrace alluvium (Holocene and Pleistocene) - Sand, silt, clay, and gravel in terraces above flood plains, mostly along Weber and Ogden Rivers; 0 to at least 20 feet (0-6 m) thick; present about 20 and 35 feet (6 and 10.5 m) above the Weber River flood plain, but below the Provo shoreline, with a lower terrace present in Ogden Valley.

Qaf Alluvial-fan deposits, undivided (Holocene and Pleistocene) - Mostly sand, silt, and gravel that is poorly bedded and poorly sorted; includes debris flows, particularly in drainages and at drainage mouths (fan heads); generally less than 60 feet (18 m) thick. Mapped where fan age uncertain or for composite fans where portions of fans with different ages cannot be shown separately at map scale.

Qaf1, Qafy

Younger alluvial-fan deposits (Holocene and uppermost Pleistocene) - Mostly sand, silt, and gravel that is poorly bedded and poorly sorted; includes debris flows, particularly in drainages and at drainage mouths (fan heads); generally less than 40 feet (12 m) thick. Near late Pleistocene Lake Bonneville, deposits with suffixes 1 and y are younger than Lake Bonneville (mostly Holocene), are active, and impinge on present-day drainages like the Weber River and Cottonwood Creek; Qafy fans may be partly older than Qaf1 fans, and may be as old as uppermost Pleistocene Provo shoreline.

Qafp, Qafb, Qafo

Older alluvial-fan deposits (upper and middle(?) Pleistocene) - Incised fans of mostly sand, silt, and gravel that is poorly bedded and poorly sorted; includes debris flows, particularly in drainages and at drainage mouths (fan heads); generally less than 60 feet (18 m) thick.

Fans labeled Qafp and Qafb are graded to the Provo (and slightly lower) and Bonneville shorelines of late Pleistocene Lake Bonneville, respectively. Near Lake Bonneville, unit Qafo is older than (above and typically incised/eroded at) the Bonneville shoreline; upstream unit Qafo is topographically higher than fans graded to the Bonneville shoreline (Qafb). Elsewhere relative-age letters only apply to local drainages. Like Qa and Qat suffixes, ages are partly based on heights above present drainages (table 1), in this case heights at drainage-eroded edge of fan, with Qafp about 35 to 45 feet (10 to 12 m) above, Qafb 50 to 75 feet (15-23 m) above, and Qafo about 70 to 110 feet (20-35 m) above present drainages. Dates presented in Sullivan and Nelson (1992) imply Qafo to southeast in Morgan quadrangle considerably predates Lake Bonneville and is middle Pleistocene in age (300-600 ka). This means these older fans could be related to Pokes Point lake cycle (at about 200 ka, after McCoy, 1987) (Kansan continental glaciation?, 300-400 ka) and/or pre Pokes Point (Nebraskan continental glaciation?, >500 ka); however, the Bonneville shoreline is obscure on this fan.

Qafoe Eroded old alluvial-fan deposits (middle and lower Pleistocene) - Eroded fans located above and apparently older than pre-Lake Bonneville older alluvial deposits (Qafo, Qao); contains mostly sand, silt, and gravel that is poorly bedded and poorly sorted; less bouldery and lower relative to high-level alluvium (for example QTao, QTaf); more than 120 feet (35 m) above present streams on east side of Morgan Valley and over 400 feet (120 m) above Weber River in southeast Snow Basin quadrangle; 0 to 60 feet, or more (0-18+ m) thick; likely same age as Qaoe (>730ka-pre Pokes Point lake cycle, Nebraskan continental glaciation?).

Qa, Qay, Qap, Qab, Qao

Alluvium, undivided (Holocene and Pleistocene) - Sand, silt, clay, and gravel in stream and alluvial-fan deposits; composition depends on source area; deposits lack fan shape and are distinguished from terraces based on upper surface sloping toward adjacent drainage like an alluvial fan; relative ages indicated by letter suffixes; Qa with no suffix used where age uncertain or alluvium of different ages cannot be shown separately at map scale; generally 0 to 20 feet (0-6 m) thick, but Qap is up to about 50 feet (15 m) thick.

Near late Pleistocene Lake Bonneville, alluvium labeled y is mostly Holocene in age; alluvial deposits labeled Qap and Qab are graded to the Provo and Bonneville shorelines, respectively; here, letter o suffix means the alluvium is older than Lake Bonneville. Elsewhere relative-age letters y and o only apply to local drainages. In this and adjacent quadrangles, ages of alluvium, including terraces and fans, are partly based on heights above present drainages (table 1); here Qay is about 15 to 20 feet (5-6 m) above, Qap is about 25 to 45 feet (8-14 m) above, and Qab is 50 to 90 feet (15-27 m) above; Qao is 100 to 145 feet (30-45 m) above present drainages and is likely the same age as Qafo (300-600 ka).

A prominent surface ("bench") is present on Qap at about 4900 feet (1494 m) along the South Fork of the Ogden River and along the Weber River in Morgan Valley (Snow Basin, Peterson, Durst Mountain, and Morgan quadrangles), about 25 to 40 feet (8-14 m) above the Weber River, with the Provo shoreline at elevations of 4800 to 4840 feet (1463-1475 m) near the head of Weber Canyon and in uppermost Ogden Canyon, respectively.

Qaoe Pleistocene alluvium (middle and lower Pleistocene) - Eroded alluvium located above the Bonneville shoreline (at 5180 feet [1580 m] in area) and apparently above and older than pre-Lake Bonneville older alluvium (Qao and Qafo); mapped on benches about 160 to 215 feet (50-65 m) above Weber River on west side of Morgan Valley in Peterson quadrangle, at an elevation of about 5300 to 5350 feet (1615-1630 m); this is slightly higher than on east side of Morgan Valley (120-200 feet [35-60 m] above), Snow Basin, Durst Mountain, and Morgan quadrangles; unit contains mostly sand, silt, and gravel in stream and alluvial-fan deposits; about 10 feet (3 m) thick; west of Weber River in Morgan quadrangle, dated by Sullivan and others (1988) as older than 730 ka, based on reversed paleomagnetism.

Lacustrine Deposits

Qly Young lacustrine deposits (Holocene) - Deposits in marshy area near Maples recreation area; may be underlain by glacial deposits; lake may have formed due to landslide damming; likely less than 20 feet (6 m) thick.

Ql Lake Bonneville deposits, undivided (upper Pleistocene) - Silt, clay, sand, and cobbly gravel; mapped where grain size is mixed or surface weathering obscures grain size and deposits are not exposed in scarps and construction cuts; thickness uncertain.

Qlg Lake Bonneville gravel (upper Pleistocene) - Mostly interbedded gravel and sand deposited along beaches and slightly offshore. Includes Bonneville-level bar and transgressive beach deposits on Strawberry Creek fan-delta and deposits in Interstate Highway 84 road cut in Weber Canyon; likely less than 20 feet (6 m) thick.

Qls Lake Bonneville sand (upper Pleistocene) - Mostly sand with some silt and gravel deposited nearshore in Morgan Valley; typically less than 20 feet (6 m) thick, but thicker in "bench" east of Cottonwood Creek in southeast corner of Snow Basin quadrangle.

Qlf Lake Bonneville fine-grained deposits (upper Pleistocene) - Mostly silt, clay, and fine sand (typically eroded from shallow Norwood Formation) in Ogden and Morgan Valleys; deposited near- and off-shore in lake; red laminated claystone at least 30 feet (9 m) thick on Frontier Drive in Snow Basin quadrangle (Rogers, 1986, borehole 1).

Glacial Deposits

Qg, Qga

Glacial till and outwash, age not known (Holocene and upper and middle Pleistocene) - Qg is undivided glacial deposits (till and outwash) of various ages; till is non-stratified, poorly sorted clay, silt, sand, and gravel, to boulder size; Qgm (moraines of unknown age) are not mapped separately from Qg in this quadrangle; outwash (Qga) is stratified and variably sorted, but better sorted and bedded than till due to alluvial reworking; Qga is mapped directly downslope from other glacial deposits where it is thick enough to obscure older deposits and bedrock, and where it can be separated from ground moraine (mapped as Qg) and alluvium (Qa_); all glacial deposits locally include mass-movements (Qms, Qmt, Qct) and rock glaciers (Qgr) that are too small to show at map scale; 0 to 150? feet (0-45? m) thick. Even where undivided are mostly Pinedale-age, that is younger deposits (Qgy); correlations of outwash with alluvial deposits have not been determined.

Qgy, Qgmy, Qgay

Younger glacial till and outwash (Holocene and upper Pleistocene) - Mostly Pinedale-age (~15,000 to 30,000 years old, upper Pleistocene) deposits mapped as undivided (Qgy), distinct moraines (Qgmy), and outwash (Qgay); moraines are mapped where distinct shapes of end, recessional, and lateral moraines are visible; mapped moraines have poorly developed soil and moderate to sharp moraine morphology (m5 and m4 moraine crests); upslope these younger units include vegetated recessional deposits from glacial stillstands and/or minor advances (deglacial pauses) about 13,000 to 14,000 years ago (m3 moraine crests); in cirques include 8,000- to 10,000-year-old and possibly middle Holocene (about 5,000 years old) deposits with very poorly developed soil and sharp, mostly non-vegetated moraines (m2 and m1 crests, respectively; m1 only present to west in Ogden 7.5' quadrangle); downslope from Pinedale moraine are likely older glacial deposits (Qgo, Qgmo, Qgao). M5 moraines may be Bull Lake age (see Madsen and Currey, 1979).

Qgo, Qgmo, Qgao

Older glacial till and outwash (middle[?] Pleistocene) - Mapped down drainage from and locally laterally above Pinedale deposits as undivided (Qgo), till in distinct vegetated moraines (Qgmo), and outwash (Qgao); see differences under undivided and younger glacial units; mapped moraines have well-developed soil and subdued moraine morphology (BL and possibly m5 moraine crests); likely Bull Lake age (~110,000 to 150,000 yrs old; see for example Chadwick and others, 1997, and Phillips and others, 1997); 0 to 150? feet (0-45? m) thick.

Deposits in Maples area are much farther from cirques that any other deposits and might be related to Kansan continental glaciation (300-400 ka) (Pokes Point lake cycle, >200 ka - McCoy, 1987), or be some pre-Pokes Point glaciation (possibly Nebraskan continental glaciation, >500 ka; or Sacagawea Ridge age, ~600 ka - Chadwick and others, 1997) (see also Phillips and others, 1997). Qgo near Strawberry Bowl base lodge seems to “lie on” Qafoe, so could be pre Pokes Point or unit is Qafo rather than Qafoe.

Qgr Rock glacier deposits (Holocene and uppermost Pleistocene) - Angular, mostly cobble- to boulder-sized debris with little matrix in un-vegetated mounds with lobate crests; includes pro-talus ramparts; probably inactive (no ice matrix); mapped separately near Strawberry Bowl; may be as much as about 10,000 years old and as young as Little Ice Age (A.D. 1500 to 1800); likely 0 to 30 feet (0-9) thick.

Mass-Movement Deposits

Qmdf Debris- and mud-flow deposits (Holocene and uppermost Pleistocene) - Poorly sorted, clay- to boulder-sized material, typically with distinct natural lateral levees, channels, and lack of vegetation; older deposits can be vegetated; 0 to 40 feet (0-12 m) thick.

Qms, Qms1, Qmsy, Qmso

Landslide and slump deposits (Holocene and Pleistocene) - Poorly sorted clay- to boulder-sized material; locally includes flow deposits; generally characterized by hummocky topography, main and internal scarps, and chaotic bedding in displaced blocks; composition depends on local sources; morphology becomes more subdued with time and amount of water in deposits; Qms may be in contact with Qms when two different slide/slumps abut; locally, unit involved in slide/slump is shown in parentheses where a nearly intact block is visible; Qms and Qmso queried (?) where bedrock block may be in place; thickness highly variable, boreholes in Rogers (1986) show thicknesses of about 20 to 30 feet (6-9 m) on small slides/flows.

Qms without suffix is mapped where age uncertain (though likely Holocene and/or upper Pleistocene), where portions of slide/slump complexes have different ages but cannot be shown separately at map scale, or where boundaries between slides/slumps of different ages are not distinct. Estimated time of emplacement indicated by relative-age number and letter suffixes with: 1 - likely emplaced in the last 80 to 150 years, mostly historical; y - post- Lake Bonneville in age and mostly pre-historic; and o - likely emplaced before Lake Bonneville transgression. Suffixes y (as well as 1) and o indicate probable Holocene and Pleistocene ages, respectively. Qmso typically mapped where rumpled morphology typical of mass movements has been diminished and/or younger surficial deposits cover or cut Qmso. These older deposits are as unstable as other landslides and slumps, and are easily reactivated with the addition of water, be it irrigation or septic tank drain fields.

Qmc Landslide and slump, and colluvial deposits, undivided (Holocene and Pleistocene) - Mapped where landslides and slumps are difficult to distinguish from colluvium (slopewash and soil creep) and where mapping separate, small, intermingled areas of slides and slumps, and colluvial deposits is not possible at map scale; locally includes talus and debris flows; typically mapped where landslides and slumps are thin ("shallow"); also mapped where the blocky or rumpled morphology that is characteristic of landslides and slumps has been diminished ("smoothed") by slopewash and soil creep; composition depends on local sources; 0 to 40 feet (0-12 m) thick. These deposits are as unstable as other landslides and slumps units (Qms_).

Qmrf Rock-fall deposits (Holocene) - Angular debris from granule to boulder size with minor fine matrix at the base of cliff comprised by Cambrian Nounan and St. Charles Formations in Ogden Canyon; mostly in Huntsville quadrangle; likely less than 40 feet (12 m) thick.

Qmt Talus (Holocene and Pleistocene) - Angular debris at the base of and on steep slopes; only larger debris fields can be shown at map scale and include colluvium locally; grades laterally into Qct; 0 to 30 feet (0-9 m) thick.

Qct Colluvium and talus (Holocene and Pleistocene) - Angular debris at the base of and on steep, typically vegetated slopes; prominent in cirques on the east flank of the Wasatch Mountains; 0 to 30 feet (0-9 m) thick.

Qc Colluvium (Holocene and Pleistocene) - Includes materials moved by slopewash and soil creep; composition depends on local sources; generally 6 to 20 feet (2-6 m) thick; not mapped where less than 6 feet (2 m) thick.

Qcg Gravelly colluvial deposits (Holocene and Pleistocene) - Present downslope from gravel-rich deposits of various ages (for example, units Tcg, QTaf, Qafoe/Qaoe, Qafo/Qao); typically differentiated from colluvium and residual gravel (Qc, Qng) by prominent stripes trending downhill on aerial photographs; stripes are concentrations of gravel up to boulder size; generally 6 to 20 feet (2-6 m) thick; stone stripes are prominent on Durst Mountain in the southeastern Snow Basin quadrangle.

Mixed Deposits

Qac Alluvium and colluvium (Holocene and Pleistocene) - Includes stream and fan alluvium, colluvium, and, locally, mass-movement deposits; 0 to 20 feet (0-6 m) thick.

Qla Lake Bonneville deposits and alluvial deposits, undivided (Holocene and uppermost Pleistocene) - Mostly poorly sorted and poorly bedded sand, silt, and clay, with some gravel; mapped where Lake Bonneville deposits are reworked by later stream action or covered by stream wash and where lake deposits are thin and overlie older alluvial deposits; deposits typically eroded from shallow Norwood Formation; thickness uncertain.

Qng Colluvial and residual gravel deposits (Holocene and Pleistocene?) - Gravel of uncertain origin, but probably mostly colluvium and residuum; poorly sorted pebble to boulder gravel in a matrix of silt and sand; mostly gravel-armored surfaces; present on high-level fan (QTaf) near head of Strawberry Creek; generally 6 to 20 feet (2-6 m) thick.

Qmg Mass-movement and glacial deposits, undivided (Holocene and Pleistocene) - Mapped where glacial deposits lack typical moraine morphology, and appear to have failed and moved down slope; also mapped in upper Strawberry Bowl where glacial deposits have lost their distinct morphology and the contacts between them and colluvium and talus in the cirques cannot be mapped; likely less than 30 feet (9 m) thick.

Qmtr Talus and rock glaciers, with some colluvium (Holocene and Pleistocene) - Angular debris at the base of and on steep slopes and lobate mounds at the base of talus slopes in cirques; mounds called pro-talus ramparts by some workers and rock glaciers by others; 0 to 30 feet (0-9 m) thick.

Qdlp, Qdlb

Lake Bonneville deltaic and lacustrine deposits, undivided (upper Pleistocene) - Mostly sand, silty sand, and gravelly sand deposited near shore. Qldb deposited as the lake transgressed to and was at the Bonneville shoreline; mapped along Cottonwood Creek upstream from Qls and in Morgan Valley, where it is more gravel rich and cobbly; at least 40 feet (12 m) thick. Qdlp mapped in single exposure south of Weber River, possibly deposited in fan-delta complex, when the lake was at and slightly below the Provo shoreline; thickness not known.

Qfd, Qfdb, Qfdp

Lake Bonneville alluvial-fan and delta deposits, undivided (upper Pleistocene) - Cobbly gravel, sand, silt, and clay deposited above (subaerial) and in Lake Bonneville (subaqueous); typically mapped where shorelines are obscure, so that line cannot be drawn between fan and delta; typically better sorted delta and lake deposits over poorly sorted alluvial-fan deposits; Qfdb mapped above the Provo shoreline and deposited as lake transgressed to Bonneville shoreline; Qfdp mapped below/near the Provo shoreline; fan deltas best developed near head of Weber Canyon with likely Provo- and Bonneville-level deposits along Strawberry Creek; also present in Weber Canyon (Qfdp); at least 40 feet (12 m) thick.

Human Deposits

Qh Human disturbance (Historical) - Obscures original deposits by cover or removal; mostly fill along railroad and highway grades, and some large gravel pits that predate 1986 aerial photographs.

QUATERNARY AND TERTIARY

QTao High-level alluvium (lower Pleistocene and/or Pliocene) - Gravel, sand, silt, and clay above other stream-terrace and alluvial-fan deposits; typically more bouldery than lower alluvium (including units Qafoe and Qaoe); at least locally gravel-armored and poorly sorted; in adjacent quadrangles, divided into younger (y) and older (o) based on height of deposits above drainages (see table 1) and elevation difference of more than 150 feet (45 m) on adjacent deposits; present about 320 to 800 feet (100-240 m) above the Weber River in Morgan Valley and decreasing upslope to about 200 to 240 feet (60-75 m) above adjacent streams; located above Qaoe, so older than 730 ka; estimate 30 to 70 feet (9-20 m) thick, based on thicknesses in Morgan Valley (Durst Mountain, Snow Basin, Morgan, and Peterson quadrangles).

QTaf High-level alluvial-fan deposits (lower Pleistocene and/or Pliocene) - Gravel, sand, silt, and clay above other stream-terrace and alluvial-fan deposits (including QTa in adjacent quadrangles); typically more bouldery than alluvium lower than QTao (and QTa in adjacent quadrangles) (including units Qafoe and Qaoe); at least locally gravel-armored and poorly sorted; present about 320 to 1000 feet (100-300 m) above the Weber River in Morgan Valley and decreasing up slope to about 235 feet (70 m) above adjacent streams; label used on recognizable fan south of Weber River and on margin of this fan over Norwood Formation (QTaf/Tn), though the margin may be older; 30 to 80 feet (9-25 m) thickness measured on stereoplotter to top of mass movement failure zone/white zone/ "bedding plane", with another failure zone about 160 feet (50 m) below surface of fan (exposed in eroded fan edge near Weber River). QTaf label also used on fan-head remnants north of Weber River near head of Strawberry Creek; estimate 30 to 160 feet (9-50 m) thick.

Upper surfaces of these high-level deposits with other high-level alluvium (QTa_) in the Durst Mountain, Peterson, and Snow Basin quadrangles appear to be the Weber Valley surface of Eardley (1944); however, high-level alluvial fans (QTaf) extend to the mountain front at elevations of about 6800 to 7200 feet (2070-2195 m), rather than to the mountain ridgelines as suggested by Eardley (1944).

Thin remnants of high-level alluvial deposits (QTao, QTaf) (boulder lags with unmappable extents) are present on some ridges in the Snow Basin quadrangle, for example between the new and old Snow Basin ski area access roads (southeast T. 6N., R. 1E.) and in NW1/4 section 14, T. 5N., R. 1E..

TERTIARY

Ts Tertiary strata, undivided - Used in landslide blocks, for example near Snow Basin Resort and on the east margin of the quadrangle where multiple units are in blocks or exact unit is uncertain.

Tcg Unnamed Tertiary conglomeratic rocks (Oligocene?) - Characterized by rounded, pebble- to boulder-sized, quartzite-clast conglomerate with less than 10 to more than 50 percent gray, tan, or reddish claystone/mudstone matrix; interbedded with tan, gray and reddish-brown, pebble-bearing mudstone to sandstone and some claystone (altered tuff); most beds poorly indurated and poorly exposed; some non-conglomeratic beds in Tcg look like the gray upper Norwood Formation (Tn) and are locally tuffaceous; some pebble beds have carbonate and chert (like Norwood) and lesser quartzite clasts; quartzite clasts are recycled Wasatch Formation clasts; to east in Durst Mountain quadrangle, conglomerates include rare altered tuff clasts from Norwood Formation (Tn); locally erodes to gravel-covered slopes with stone stripes in southeast corner of Snow Basin quadrangle; locally includes landslides, slumps, and flows that are too small to show at map scale; only base of unit is exposed in Snow Basin quadrangle and thickness is uncertain.

In better exposures in the Durst Mountain quadrangle, conglomeratic strata (Tcg as well as units Tcw, Tct, Tca) are an estimated 500 feet (150 m) thick in aggregate and thicken northward to possibly 3000 feet (900 m) thick, though faulting may make this estimate too large (see Coogan and King, 2006); previously included in Huntsville fanglomerate (compare Eardley, 1955; Lofgren, 1955; and Coody, 1957 to Coogan and King, 2006).

In most of the Snow Basin and Durst Mountain quadrangles north of Cottonwood Creek, the Tcg-Norwood (Tn) contact is placed at the bottom of the lowest quartzite-cobble bed that is at least 6 feet (2 m) thick and is partly based on regular bedding and reddish-brown strata in Tcg. This contact is problematic because the relatively thin, non-resistant, quartzite-clast beds are in a thick interval that looks like interbedded upper Norwood Formation and quartzite-clast conglomeratic strata, and the quartzite-clast beds grade northward in the quadrangles into Norwood sandstone and pebble beds (see also Coogan and King, 2006). In the northeast part of the Snow Basin quadrangle the Tcg-Tn contact is placed at the top of a light-colored claystone bed as the quartzite-cobble bed defining the contact thins below 6 feet (2 m) in thickness and clasts become less abundant and smaller than cobble size. Based on bedding dips, this claystone bed should be present west of Strong Hollow, but it is not identifiable there nor are cobbles present. Therefore the Tcg-Tn contact is somewhat arbitrarily placed in Strong Hollow. The lack of an angular unconformity at any of these quartzite-clast beds means the Norwood and at least the lower part of this unit (Tcg) are interbedded.

Tn Norwood Formation (lower Oligocene and upper Eocene) - Typically light-gray to light-brown, altered tuff (claystone), tuffaceous siltstone, sandstone, and conglomerate; locally colored light shades of red and green; variable calcareous cement and zeolitization, that is less common to south of Snow Basin quadrangle; zeolite marker beds mapped as an aid to recognizing geologic structure; locally includes landslides and slumps that are too small to show at map scale.

Upper Norwood Formation, as exposed on east margin of Snow Basin quadrangle and to east in Durst Mountain quadrangle, contains interbedded claystone (tuffaceous beds), fine- to coarse-grained sandstone, gray granule to small pebble conglomerate, with chert and carbonate clasts, as well as conglomerate interbeds with quartzite pebble clasts like those in unit Tcg; interbedded with more extensive quartzite-clast conglomerate, some mapped as Tcg, to east in Durst Mountain quadrangle (see Coogan and King, 2006); north of Wasatch Formation (Tw) knob on Snow Basin-Durst Mountain quadrangle boundary, the Norwood contains intermittent quartzite gravel (quartzite-richest exposures mapped as Tcg?); also, gravel-rich beds containing mostly chert and carbonate clasts are common north of the knob, and with quartzite-bearing beds, are involved in multiple landslides that obscure bedding and structure; these variations and disruptions make it difficult to map a consistant Tcg-Tn contact (see also unit Tcg description above and in Coogan and King, 2006); based on outcrop pattern, dip, and topography, Norwood is at least 7000 feet (2135 m) thick in Snow Basin quadrangle; it thins to the south, so is about 5000 feet (1525 m) thick north of Morgan, and only about 1500 feet (460 m) thick east of East Canyon Creek in the type area in Porterville quadrangle (Eardley, 1944) (not 2500+ feet [800+ m] inferred by Bryant and others, 1989, p. K6).

Zeolite beds mapped in the Norwood indicate a generally east-dipping homocline with minor faulting. A broad, north-south-oriented, doubly plunging syncline is superimposed on the homocline but the east limb of the syncline and companion anticline are obscured by landslide complexes. The common fold limb may dip steeply to the west. Also the zeolite beds become obscure to the east, due to the increased abundance of clastic sediment, making the zeolite beds thinner and less pure, and therefore less distinct.

Norwood generally considered younger than the Fowkes Formation, but not well dated due to alteration. Corrected Norwood K-Ar ages are 38.4 Ma (sanidine) from Norwood type area (Evernden and others, 1964) and 39.3 Ma (biotite) from farther south in East Canyon (Mann, 1974), while Fowkes $^{40}Ar/^{39}Ar$ ages are 40.41 Ma and 38.78 Ma on biotite and hornblende, respectively, from Utah to east near Wyoming (Coogan and King, unpublished). To north in southern Cache Valley, basal part of unit similar to Fowkes and Norwood ("resting" on Wasatch and less than 600 feet [180 m] or about 1200 feet [260 m] thick) dated at 44.2 $\pm$ 1.7 Ma and 48.6 $\pm$ 1.3 Ma K-Ar on hornblende and biotite, respectively (Smith, 1997; King and Solomon, 2008); though the biotite date is suspect, its age is similar to older dates on the Fowkes Formation in Wyoming, which are: 47.94 $\pm$ 0.17 Ma ($^{40}Ar/^{39}Ar$, sanidine) at the northeast end of the Crawford Mountains (Smith and others, 2008, p. 67), south of the Fowkes type area (see Oriel and Tracey, 1970); 49.1 Ma (biotite; recalculated; dated in 1977, but decay constant not reported, so may not need to be recalculated), reported as 47.9 $\pm$ 1.9 Ma by Nelson (1979) and likely from near the base of the Fowkes near Evanston, Wyoming (Nelson, 1973); and 48.9 Ma K-Ar (hornblende; recalculated) from the Fowkes type area near Leefe, Wyoming (47.7 $\pm$ 1.5 Ma, Oriel and Tracey, 1970).

The Norwood is different in the southern Peterson and Morgan quadrangles, near the type area (see Eardley, 1944), where it contains extensive unaltered tuff (hence the name Norwood Tuff), has cut-and-fill structures (fluvial), and includes volcanic-clast conglomerate; in the Morgan quadrangle, it also contains local limestone and silica-cemented rocks. Unit referred to here as Norwood Formation, rather than Norwood Tuff, because the type area includes only part of the formation (see thickness in following paragraph), the Norwood contains many lithologies, and this emphasizes that it is not tuffaceous away from the type area.

Tw Wasatch Formation (Eocene and uppermost Paleocene) - Typically red-weathering conglomerate, as well as lesser sandstone, siltstone, and mudstone; clasts typically rounded and from Precambrian and Paleozoic rocks; lighter shades of red, yellow/tan, and light gray more common in upper Wasatch near contact with Norwood; basal conglomerate less likely to be red since dominated by locally derived material, with clasts of lower Paleozoic carbonates in the Maples area, and Precambrian crystalline rocks and Cambrian Tintic Quartzite west of Strawberry Creek; Wasatch knob on east margin of Snow Basin quadrangle is light-gray to brownish-gray, variably cemented conglomerate that contains angular pebble-sized Tintic clasts; thickness varies due to relief on basal and overlying erosional surfaces; thickness uncertain, in the Snow Basin quadrangle about 560 feet (170 m) exposed west of Strawberry Creek, additional estimated (partially exposed) 750 feet (230 m) east of creek may be fault repetition; on opposite (east) side of Morgan Valley in southeast Morgan quadrangle and southwest Devils Slide quadrangle, total thickness estimated by King as 5000 to 6000 feet (1500-1800 m), based on dip (20-

25^{o}), outcrop pattern, and topography; locally includes landslides and slumps that are too small to show at map scale. On east margin of Snow Basin quadrangle near knob of Wasatch Formation, a light-gray to light-brown, carbonate and quartzite (mixed) clast, pebble conglomerate that might be Tw or Tcg is mapped as Tw?.

On this knob, the Wasatch Formation, possibly along with Norwood strata, is apparently draped over a paleo-topographic high of intensely fractured Cambrian Tintic Quartzite. This knob is: (1) an exotic block emplaced before or during Wasatch deposition; (2) an exposure of the Cretaceous Ogden thrust fault zone; or (3), and more likely, a part of the Tertiary (post-Wasatch) normal fault zone that is better exposed on the west flank of Durst Mountain, about 2 to 3 miles (3-5 km) to the southeast (see Coogan and King, 2006).

CRETACEOUS

KXc Chloritic gneiss, cataclasite, mylonite, and phyllonite (Cretaceous and[?] Proterozoic) - Dark- to gray-green, variably fractured and altered rock with local micaceous cleavage; contains variable amounts of fine-grained, recrystallized chlorite, muscovite, and epidote; present in shear and fracture zones, and in diffuse altered zones associated with quartz pods that crosscut basement rocks (Yonkee, 1992; Yonkee and others, 1997); locally includes quartz veins in Snow Basin quadrangle (see Bryant, 1988, p. 5-6, 8); some linear zones of this unit mapped as faults by Bryant (1988); produced by mostly Cretaceous deformation and greenschist-facies alteration that overprints various Farmington Canyon complex protoliths (Yonkee and Lowe, 2004); however, Bryant (1988) indicated that some quartz veins and pods may be related to Precambrian alteration.

OGDEN THRUST SHEET

These strata are a transitional shelf sequence between deeper-water strata now exposed on the Willard thrust sheet and shallower-water strata exposed to the east on the Crawford thrust sheet (see for example Coogan, 1992). Therefore the use of Devonian Beirdneau, Hyrum, and Water Canyon names, along with Cambrian St. Charles, Nounan, and Bloomington names from the outer shelf sequence (Willard thrust sheet) may not be appropriate for strata in the Ogden thrust sheet. We chose to retain these formation names because they have been used previously (Rigo, 1968; Sorensen and Crittenden, 1979; Crittenden and Sorensen, 1985; Yonkee and Lowe, 2004), previous work on the Devonian and upper Cambrian strata in the area is confusing (see previous references as well as Eardley, 1944; Eriksson, 1960; Coogan and King, 2006), and, except for the Water Canyon, the strata, though thinner, are like that on the Willard thrust sheet.

Further complicating the geology, Silurian and some Ordovician strata are missing in the area (for example, Laketown Dolomite and Swan Peak Quartzite), and Devonian through upper Cambrian strata are thinner over the Stansbury uplift and Tooele arch (see Hintze, 1959; Rigby, 1959). Also, strata of the Ogden thrust sheet have been tectonically thinned and duplicated to triplicated during movement on the Ogden and Willard thrust faults (see for example Yonkee and others, 1997; Yonkee and Lowe, 2004). This means map-unit thicknesses are highly variable and, though we have attempted to present numbers that are undeformed thicknesses, the thicknesses reported may not be pre-deformation thicknesses.

MISSISSIPPIAN

Mh Humbug Formation - Gray- to tan-weathering, thin- to thick-bedded, variably dolomitic sandstone, dolomite, limestone, and minor black shale; forms ledges and cliffs; local black chert, mostly in pods; about 700 to 1000 feet (215-300 m) thick in area (see for example Sorensen and Crittenden, 1974), but top not exposed in quadrangle; thickness uncertain because of complex folding (see Pavlis, 1979); about 700 feet (215 m) thick to east on Durst Mountain (Coogan and King, 2006).

Mde Deseret Limestone - Pale-brown-weathering, thin-bedded dolomite and limestone, with phosphatic shale at base (Delle Phosphatic Shale Member); forms ledges; shale covers Gardison bench or forms non-resistant recess; reportedly 200 to 250 feet (60-75 m) thick in Ogden Canyon area (Sorensen and Crittenden, 1972, 1974), with about 18 feet (5 m) of Delle (after Cheney, 1957, p. 37; Eriksson, 1960; Schell and Moore, 1970); thickness uncertain in Snow Basin quadrangle, because about 500 feet (150 m) thick to east on Durst Mountain (Coogan and King, 2006) and estimate Deseret and Gardison together are about 660 feet (200 m) thick in Ogden Canyon area (this report).

Mg Gardison Limestone - Medium- to dark-gray, thin- to thick-bedded, fossiliferous limestone and dolomitic limestone; typically forms upper and lower cliff and middle slope and ledges; contains gray to black chert pods and stringers, and widespread crinoid and brachiopod fossil fragments; bedding becomes thicker upward; about 300 to 850 feet (90-260 m) thick in Ogden Canyon area (Sorensen and Crittenden, 1974), but typically 500 to 800 feet (150-245 m) thick (Eardley, 1944; Sorensen and Crittenden, 1972; Yonkee and Lowe, 2004). Called Lodgepole on Durst Mountain and 650 to 800 feet (200-245 m) thick (Coogan and King, 2006).

DEVONIAN

Dbw Beirdneau, Hyrum, and Water Canyon Formations, undivided - Only used in structurally complex Ogden Canyon.

Db Beirdneau Sandstone - Buff- to orange-yellow- to red-weathering, calcareous, fine- to medium-grained sandstone and siltstone, interbedded with silty to sandy dolomite and limestone, and with some shale and flat-pebble conglomerate; slope forming; about 165 to 330 feet (50-100 m) thick in Ogden Canyon area (see Yonkee and Lowe, 2004); in less deformed areas, likely 250 to 300 feet (75-90 m) thick (see Sorensen and Crittenden, 1972, 1974). Argillaceous uppermost part reported in Huntsville quadrangle by Yonkee and Lowe (2004) not recognized in Snow Basin quadrangle.

Dhw Hyrum and Water Canyon Formations - Total thickness of 165 to 330 feet (50 to 100 m) reported by Yonkee and Lowe (2004) in Ogden Canyon area seems too thin given individual thicknesses.

Hyrum Dolomite - Medium- to dark-gray, brownish-weathering, medium- to thick-bedded, ledge-forming dolomite and minor silty limestone; about 200 to 350 feet (60-107 m) thick (after Sorensen and Crittenden, 1972, 1974; Yonkee and Lowe, 2004); unconformably overlies Water Canyon.

Water Canyon Formation - Light-yellow- to medium-gray, thin- to medium-bedded, interlayered, variably silty to sandy dolomite and lesser limestone and calcareous siltstone, and minor calcareous sandstone; less resistant than underlying and overlying units; 30 to 100 feet (9-30 m) thick in Ogden Canyon area (Yonkee and Lowe, 2004), too thin to map separately; unconformably overlies Fish Haven with Laketown Dolomite missing; Water Canyon about 200 feet (60 m) thick to east on Durst Mountain, but other Devonian units are about the same thickness, and Silurian and Ordovician strata are absent (Coogan and King, 2006).

SILURIAN - Missing Laketown Dolomite in area, likely due to thinning over Devonian Stansbury uplift (see Rigby, 1959).

ORDOVICIAN

Ofg Fish Haven and Garden City Formations

Fish Haven Dolomite - Medium- to dark-gray, medium- to thick-bedded, slightly fossiliferous, cliff-forming dolomite; fossil crinoid and coral debris throughout; 130 to 265 feet (40-80 m) thick in Ogden Canyon (Yonkee and Lowe, 2004); in less deformed areas, likely 200 to 225 feet (60-70 m) thick (see Sorensen and Crittenden, 1972, 1974); unconformably overlies Garden City with Swan Peak Quartzite missing, an effect of the Ordovician Tooele arch (see Hintze, 1959).

Garden City Formation - Pale-gray to buff-weathering, thin- to thick-bedded, ledge- and slope-forming dolomite, silty dolomite and limestone, and minor siltstone; overall well-bedded appearance; about 200 to 400 feet (60-120 m) thick (Yonkee and Lowe, 2004).

ORDOVICIAN AND CAMBRIAN

Csn St. Charles and Nounan Formations

St. Charles Formation - Light- to medium-gray, medium- to thick-bedded, cliff-forming dolomite; about 20- to 40-foot (6-12 m) thick, calcareous sandstone and sandy dolomite that is the Worm Creek Member is locally present at base (after Rigo, 1968; Sorensen and Crittenden, 1972, 1974); 400 to 660 feet (120-200 m) thick (Rigo, 1968; Sorensen and Crittenden, 1972).

Nounan Dolomite - Medium- to light-gray, medium- to thick-bedded, cliff-forming dolomite; local “twiggy” structures; about 500 to 750 feet (150-230 m) thick in Ogden Canyon area (Yonkee and Lowe, 2004); only about 350 feet (105 m) thick 12 miles (20 km) to east on Durst Mountain (Rigo, 1968; Sorensen and Crittenden, 1979; Coogan and King, 2006), since Nounan and overlying Cambrian and Ordovician units there removed from Tooele arch and/or Stansbury uplift (see Hintze, 1959; Rigby, 1959).

CAMBRIAN

Cb Bloomington Formation - Olive-brown- to orange-brown-weathering, silty argillite interlayered with gray- to orange-gray-weathering, thin- to medium-bedded, silty limestone, flat-pebble conglomerate, oncolitic limestone, and oolitic limestone; contains nodular and wavy-bedded (ribbon) limestone; slope-forming; lithologically similar to Calls Fort (upper) and Hodges (lower) Shale Members of Bloomington Formation; *Eldoradia* sp. trilobite fossil in Ogden Canyon (Rigo, 1968) supports correlation with Calls Fort Member; estimate 66 to 165 feet (20-50 m) thick in less deformed areas, with apparent thicknesses of 40 to 200 feet (10-60 m)(after Sorensen and Crittenden, 1972; Yonkee and Lowe, 2004); not present on Durst Mountain (Coogan and King, 2006).

Cm Maxfield Limestone, undivided (Middle Cambrian) - Cross section unit; about 600 to 900 feet (180-270 m) thick in Ogden Canyon area (Rigo, 1968; after Yonkee and Lowe, 2004); only 300 feet (90 m) thick about 12 miles (20 km) east on Durst Mountain (Coogan and King, 2006); divided into subunits.

Cmu Upper members - Cliff- and ledge-forming; total about 300 to 525 feet (90-160 m) thick in area (this report).

Dolomite member - Light- to dark-gray, medium- to thick-bedded dolomite, some oolitic dolomite, and minor limestone; widespread “twiggy” structures; locally contains light-gray, silty ribbons; distinctive dark-gray, cherty dolomite and light-gray boundstone near top; 200 to 425 feet (60-130 m) thick (this report).

Upper limestone member - Light- to medium-gray, thin- to thick-bedded, oolitic limestone, micritic limestone (with light-yellowish-gray-weathering silty ribbons), and minor dolomite; about 100 to 165 feet (30-50 m) thick (this report).

Cmm Middle (argillaceous limestone) member - Includes several interbedded rock types: light- to orange-gray-weathering, wavy-bedded, argillaceous to silty limestone, with silty shale partings; olive-brown- to orange-brown-weathering, laminated argillite and silty argillite containing limestone nodules; and orange-gray-weathering, thin- to medium-bedded, oolitic limestone, oncolitic limestone, and flat-pebble conglomerate; overall slope forming with thin limestone ledges; 150 to 300 feet (45-90 m) thick (this report).

Cml Lower limestone member - Light- to medium-gray, thin- to medium-bedded, cliff-forming, micritic limestone with abundant orange-gray-weathering, wavy, silty layers, and minor oolitic limestone; slope-forming, argillaceous limestone interval near middle; sharp contact with underlying upper Ophir member; about 100 to 200 feet (30-60 m) thick (Rigo, 1968; Yonkee this report). According to Yonkee and Lowe (2004), the limestone, in which Rigo (1968) reported *Elrathia* sp. trilobite fossils in Ogden Canyon, is in this member of the Maxfield, rather than in the middle member of the Ophir Formation, as Rigo (1968) reported; *Elrathia* can be used as a proxy for the Middle Cambrian *Bolaspidella* zone (see Robison, 1976, figure 4).

Co Ophir Formation, undivided (Middle Cambrian) - Cross section unit; highly deformed in most outcrops, total apparent thickness as little as about 200 feet (60 m) (see Rigo, 1968); total thickness about 450 to 650 feet (140-200 m) (Sorensen and Crittenden, 1972) where likely less deformed; about the same thickness to east on Durst Mountain (Coogan and King, 2006); divided into subunits.

Cou Upper argillite member - Brown-weathering, dark-brown-gray to olive-gray, variably calcareous and micaceous argillite to slate with some intercalated medium-gray, silty limestone beds; slope-forming and rarely exposed; thickness highly variable but likely about 130 to 260 feet (40-80 m) thick (Yonkee and Lowe, 2004).

Com Middle limestone member - Light- to medium-gray, thin- to medium-bedded, ledge-forming, micritic limestone with local orange-gray-weathering, silty ribbons and minor oolitic limestone; forms thin ledge but locally thickened by minor folds; apparent thickness 15 to 65 feet (5-20 m) (Yonkee this report).

Col Lower argillite member - Not exposed in Snow Basin quadrangle, but likely present in shallow subsurface. Brown-weathering, dark-brown, orange-brown, and olive-gray, micaceous to silty argillite and slate; slope forming; interbedded thin siltstone and sandstone layers at base, grading downward over 33 feet (10 m) into Tintic Quartzite; apparent thickness highly variable (about 100 to 370+ feet [30-115+ m]) (after Rigo, 1968; Crittenden and Sorensen, 1985; Yonkee and Lowe, 2004) but actual thickness likely about 100 to 145 feet (30-45 m) (this report); contains *Ehmaniella* sp. trilobite fossils in Ogden Canyon (Rigo, 1968).

Ct Tintic Quartzite (Middle and Lower Cambrian) - Tan-weathering, cliff-forming, thin- to thick-bedded, very well cemented, quartz-rich sandstone, with lenses and beds of quartz-pebble conglomerate and lesser thin argillite layers; sandstone is tan, white, reddish tan and pale-orange tan with abundant cross-bedding; argillite more abundant at top and quartz-pebble conglomerate increases downward; has greenish to purplish to tan, arkosic sandstone, poorly sorted conglomerate, and micaceous argillite at base that is reportedly up to 200 feet (60 m) thick in Ogden 7.5' quadrangle (Yonkee and Lowe, 2004); unconformably overlies Farmington Canyon Complex; about 1100 to 1500 feet (335-450 m) thick in Ogden Canyon area (Sorensen and Crittenden, 1972; this report); thinner to east on Durst Mountain (~1000 feet [300 m])(Coogan and King, 2006).

On the east margin of the Snow Basin quadrangle, Wasatch and Norwood Formations are apparently draped over a knob of highly fractured, white (bleached?) Tintic Quartzite, either in an exotic block or as fault zone rocks, indicating exposure of the Ogden thrust faults or the normal fault zone on the west flank of Durst Mountain about 2 to 3 miles (3-5 km) southeast.

PROTEROZOIC (below Ogden thrust sheet)

Xfc Farmington Canyon complex, undivided (lower Proterozoic) - Granitic and migmatitic gneiss with quartz-rich gneiss and biotite-rich schist, and lesser meta-gabbro, amphibolite, and meta-ultramafic rock; includes small mafic and pegmatitic pods and dikes that are too small to show at map scale. Barnett and others (1993) reported the various isotopic ages of the complex and concluded it was Early Proterozoic (about 1700 Ma) in age. More detailed information on the complex in the adjacent Ogden 7.5' quadrangle is available in Yonkee and Lowe (2004); see also Bryant (1988) for information on the complex in the Ogden, Snow Basin, Kaysville, Peterson, and Bountiful Peak quadrangles. Locally includes landslides and slumps that are too small to show at map scale. Where possible rock types in complex divided into:

Xfcm Migmatitic gneiss - Medium- to light-pink-gray, strongly foliated and layered (migmatitic) quartzo-feldspathic rock with widespread garnet and biotite; cut by variably deformed pegmatite dikes; unit also contains unmapped widespread amphibolite bodies, granitic gneiss pods, and some thin layers of sillimanite-bearing, biotite-rich schist; contact with granitic gneiss is gradational (after Yonkee and Lowe, 2004) and migmatitic gneiss seems to be interlayered with granitic gneiss west of Middle Peak (sections 17 and 20, T. 5 N., R. 1 E.).

Xfcb Biotite-rich schist - Medium-gray to dark-brown, strongly foliated, biotite-rich schist with widespread garnet and sillimanite; displays alternating biotite-rich and quartz-feldspar-rich bands that are rotated into complex fold patterns; unit cut by variably deformed, garnet-bearing pegmatite dikes; this schist unit also contains some thin layers of amphibolite, quartz-rich gneiss, and granitic gneiss; gradational contacts with migmatitic gneiss (after Yonkee and Lowe, 2004).

Xfcg Granitic gneiss - Light- to pink-gray, moderately to strongly foliated, fine- to medium-crystalline, hornblende-bearing, quartzo-feldspathic rock with minor orthopyroxene; cut by variably deformed, light-colored, pegmatite dikes; unit also contains unmapped, widespread small pods of amphibolite; contact with migmatitic gneiss is gradational (after Yonkee and Lowe, 2004) and granitic gneiss seems to be interlayered with migmatitic gneiss west of Middle Peak (sections 17 and 20, T. 5 N., R. 1 E.).

WILLARD THRUST SHEET

ZYp, ZYpp

Formation of Perry Canyon (upper and possibly middle Proterozoic) - Slate to micaceous argillite and meta-sandstone to meta-gritstone to meta-diamictite; typically non-resistant and tan weathering such that gray to green to dark-gray fresh color is seldom seen except in cut slopes and excavations; meta-sandstone contains poorly sorted lithic, quartz, and feldspar grains in silty to micaceous matrix; meta-diamictite rare in map area, north of Pineview Reservoir (north of map area) contains pebble- to boulder-sized, quartzite and granitoid clasts in sandy to micaceous argillite matrix; regionally divided into multiple members (see Crittenden and Sorensen, 1985); in map area, previously mapped as graywacke member, with 1500 feet (460 m) thickness reported in Huntsville quadrangle by Sorensen and Crittenden (1979); in present map area includes phyllite subunit (ZYpp) that is mapped separately because it was not previously reported and is very susceptible to slides, slumps, and flows; total thickness likely less than 2000 feet (600 m). Locally includes landslides and slumps that are too small to show at map scale.

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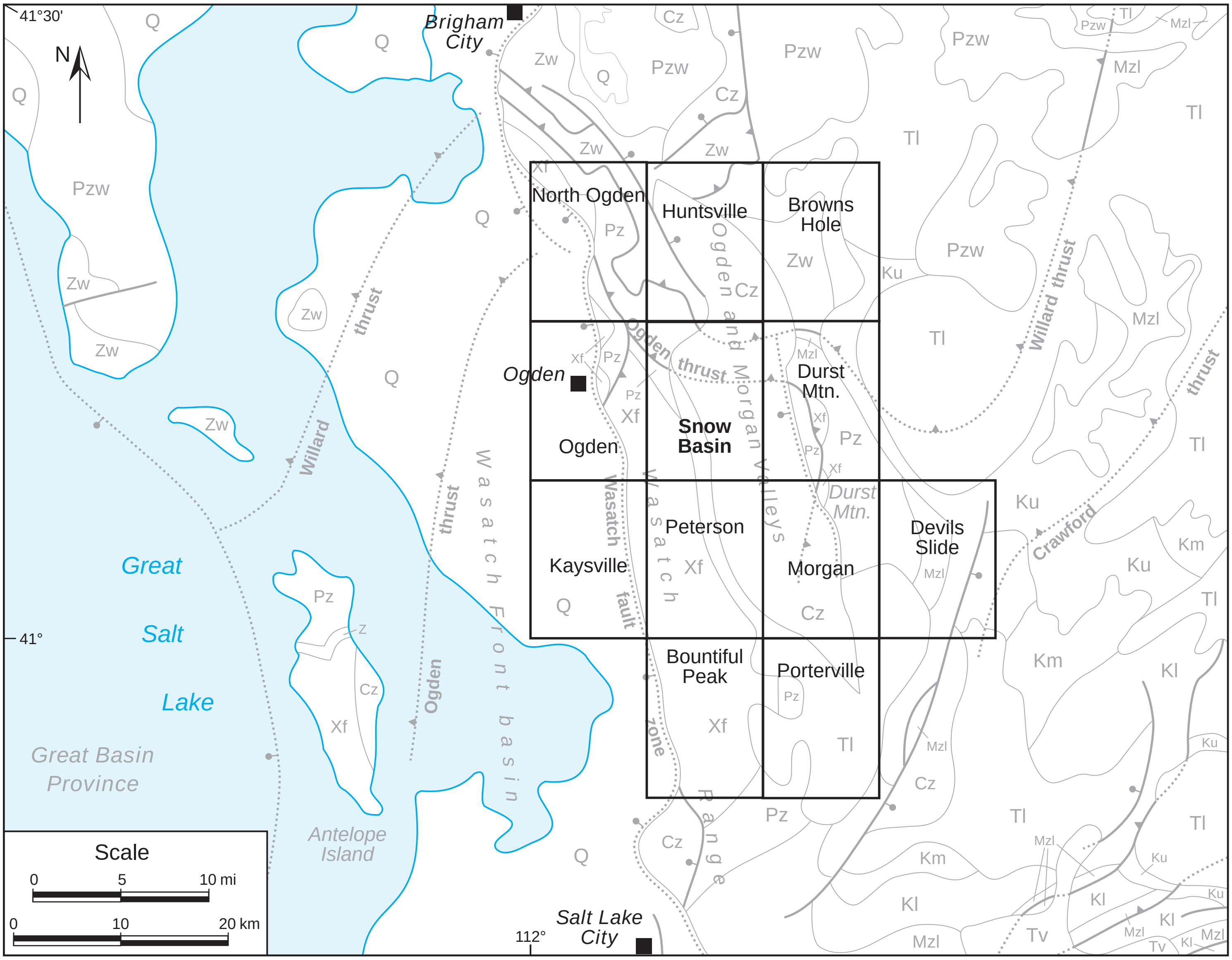
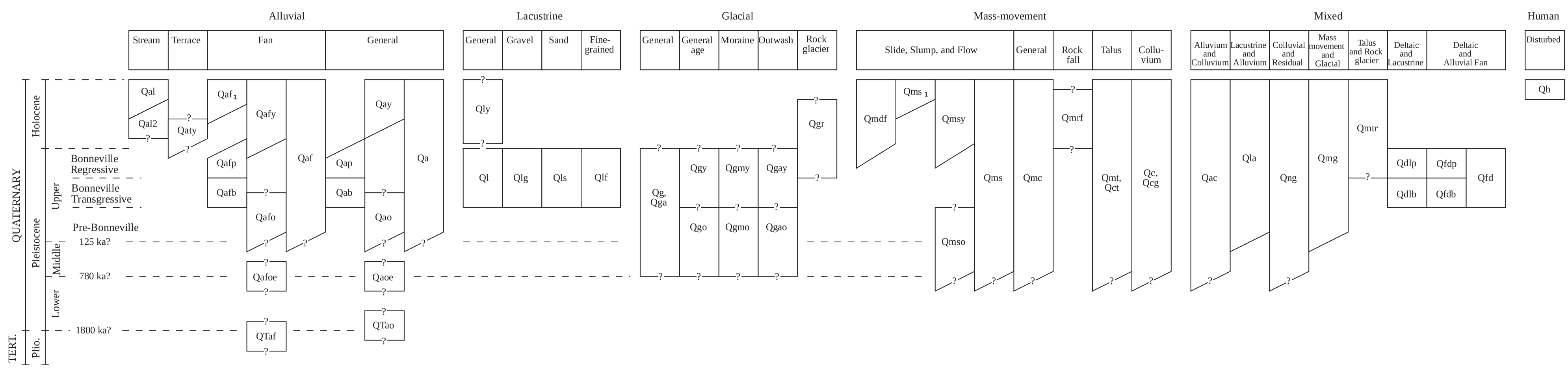


Q	Quaternary deposits	Kl	Cretaceous, lower
Cz	Cenozoic basin fill	Mzl	Mesozoic, lower
Tl	Tertiary, lower	Pz	Paleozoic
Tv	Tertiary volcanics	Pzw	Paleozoic, Willard thrust sheet
Ku	Cretaceous, upper	Zw	Late Proterozoic, Willard thrust sheet
Km	Cretaceous, middle	Xf	Farmington Canyon Complex

Table 1. Heights of alluvial deposits above adjacent active drainages in the Snow Basin quadrangle. Some units (*) and heights are from Weber River Valley in adjacent Durst Mountain, Morgan, and Peterson quadrangles. Older ages (>150ka) from information in Sullivan and others (1988) and Sullivan and Nelson (1992).

Unit(s)	Feet (m) above drainage	Age (ka=1000) years	Comments
Qal, Qay, Qafy	at to slightly above	<~10 ka	
Qa2*	~15 feet (5 m)	<~13 ka	
Qat2*	~20 feet (6 m)		
Qap	15 to 40 feet (5-12 m)		
Qatp*	25 to 30 feet (8-9 m)	~13-15 ka	
Qafp	~ 40 to 45 feet (12-14 m)		
Qab	40 to 80 feet (12-24 m)	~15-20 ka	
Qafb	> ~40 feet (>14 m)		
		~130-150 ka	"Bull Lake" glaciation-related deposits apparently absent
Qao	70 to 120 feet (20-37 m)		
Qato*	~100 feet (30 m)		
Qafo	~70 to 110 feet (20-35 m)	300-600 ka	where dated may really be Qafoe
Qaoe?*	80 to 100 feet (24-30 m)		correlation uncertain
Qaoe	120 to 200 feet (35-60 m)	>730 ka	where dated may really be QTay
Qafoe	~160 feet (50 m)		
QTay*	~160 to 300+ feet (50-90+ m)	>730 ka	
QTao	~320 to 800 feet (100-240 m)	>730 ka	
QTaf	~1000 feet (300 m)	>730 ka	may be entirely Pliocene



QUATERNARY CORRELATION CHART

Snow Basin Quadrangle

LITHOLOGIC COLUMN
Snow Basin Quadrangle

AGE	MAP SYMBOL		MAP UNIT		THICKNESS FEET	THICKNESS METERS	OTHER INFORMATION
Q.	Q- various		Surficial deposits		0-500	0-150	
	QT- various		High-level alluvium		0-160	0-50	
TERTIARY	Ts	Tcg	unnamed conglomeratic rocks		500+	150+	Tcg-Tn interbedded
	Ts	Tn	Norwood Tuff		0-7000	0-2135	Altered tuff 38.4 Ma K-Ar (corrected)
	Ts	Tw	Wasatch Formation		0-1300	0-400	MAJOR UNCONFORMITY
K.	KXc		Chloritic gneiss and tectonites		indeterminable		Farmington Canyon Complex protolith
MISSISSIPPIAN	Mh		Humbug Formation		700-1000*	215-305*	
	Mde		Deseret Limestone		200-250	60-75	Base phosphatic
	Mg		Gardison Limestone		300-850*	90-260*	Fossiliferous UNCONFORMITY?
DEV.	Db		Bierdneau Sandstone		250-300	75-90	
	Dhw		Hyrum Dolomite		200-350	60-107	UNCONFORMITY
	Dhw		Water Canyon Formation		30-100	9-30	UNCONFORMITY
ORD.	Ofg		Fish Haven Dolomite		130-265*	40-80*	UNCONFORMITY
	Ofg		Garden City Formation		200-400*	60-120*	UNCONFORMITY
CAMBRIAN	Ꞓsc		St. Charles Formation		400-660*	120-200*	Worm Creek quartzite
	Ꞓn		Nounan Dolomite		500-750*	150-230*	*Eldoradia*
	Ꞓb		Bloomington Formation		40-200*	10-60*	Intraformational conglomerate
	Ꞓm	Ꞓmu	Maxfield Limestone	upper	300-525*	90-160*	
	Ꞓm	Ꞓmm	Maxfield Limestone	middle	150-300*	40-90*	Boundstone
	Ꞓm	Ꞓml	Maxfield Limestone	lower	100-200	30-60	? *Elrathia*
	Ꞓo	Ꞓou	Ophir Formation	upper	130-260	40-80	
	Ꞓo	Ꞓom	Ophir Formation	middle	15-65*	5-20*	? *Elrathia*
	Ꞓo	Ꞓol	Ophir Formation	lower	100-145	30-45	*Ehmaniella*
	Ꞓt		Tintic Quartzite		1100-1500	335-450	MAJOR UNCONFORMITY
EARLY PROTER.	Xfc		Farmington Canyon Complex		indeterminable		1700± Ma Gneiss and schist

SCHEMATIC COLUMN

Willard Thrust Sheet

AGE	MAP SYMBOL	MAP UNIT	THICKNESS FEET	THICKNESS METERS	OTHER INFORMATION
PROT.	ZYp	Formation of Perry Canyon	<2000	<600	Meta-sedimentary Late and Middle(?) Proterozoic

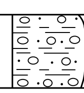
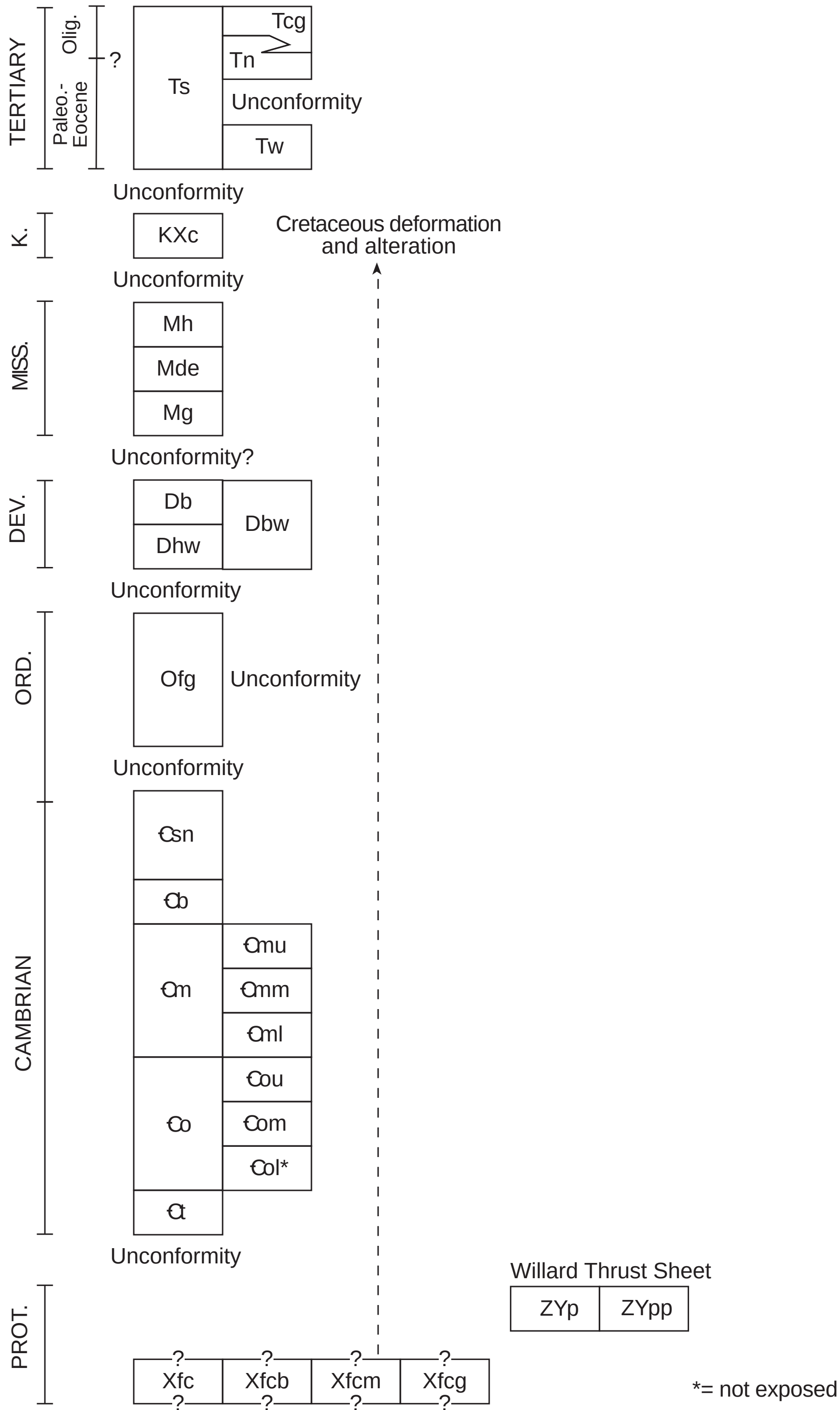


Diagram is schematic--- no fixed thickness scale

*Apparent thickness, deformed rocks



BEDROCK CORRELATION CHART

Snow Basin Quadrangle

MAP AND CROSS-SECTION SYMBOLS

Contact, dashed where approximately located or gradational, dotted where concealed

Marker bed (extrapolated where concealed) mostly in the Norwood Formation (Z with numeric suffix indicates major zeolite bed, lowest number is youngest bed; queried where correlation uncertain)

Fault, sense of movement unknown, dashed where approximately located, dotted where concealed

Normal fault, bar and ball on downthrown side, dashed where approximately located, dotted where concealed; arrow and number indicate dip on fault, determined photogrammetrically; arrows show direction of offset on cross section

Thrust fault, teeth on upper plate, dashed where approximately located, dotted where concealed; queried where existence uncertain; arrow and number indicate dip on fault, determined photogrammetrically; arrows show direction of offset on cross section

Lineament, possible fault, but offset uncertain

Synform hinge zone trace, approximately located, arrow shows plunge (extrapolated where concealed)

Antiform hinge zone trace, approximately located (extrapolated where concealed)

Overturned synform hinge zone trace, approximately located (extrapolated where concealed)

Overturned antiform hinge zone trace, approximately located (extrapolated where concealed)

Monocline (flexure) hinge zone trace, approximately located (extrapolated where concealed)

Lake Bonneville shoreline, dashed where approximately located, dotted where concealed

B Bonneville (about 5180 feet [1579 m])
X transgressional (prominent at about 5060 feet [1542 m])
P Provo (about 4840 feet [1476 m])
unlabeled (likely transgressive)

Bonneville level beach ridge, on Strawberry fan-delta

Mass-movement scarp

Moraine crest or ice-carved bedrock ridge, lowest number, m1, is youngest; queried where correlation uncertain; m1 and m2 are likely Holocene and are conspicuous to west, upslope in Ogden 7.5' quadrangle; m3, and m4 are Pinedale-age features; m5 may be Pinedale- or Bull Lake-age features; BL is Bull Lake-age features. Possible age-equivalent end moraine in Cottonwood Canyon near Salt Lake City (Madsen and Currey, 1979) in parentheses.
m1 and m2 (upper and lower Devils Castle, respectively)
m3 (Hogum Fork, double crested)
m4 (Bells Canyon)
m5 (uncertain) Correlation problem because next moraine in Cottonwood Canyon is Dry Creek, but Dry Creek moraine has well developed soil and is pre-Wisconsin (Bull Lake)

Strike and dip of bedding (red from Pavlis, 1979; purple from Sorensen and Crittenden, 1979)

43 Upright
78 Overturned
Vertical
Horizontal
50 75o+ Determined photogrammetrically, upright on left, overturned on right
Approximate (queried where dip uncertain)

60 Strike and dip of high-grade foliation (upright)

45 Strike and dip of low-grade cleavage (upright)

Fractures (near vertical)

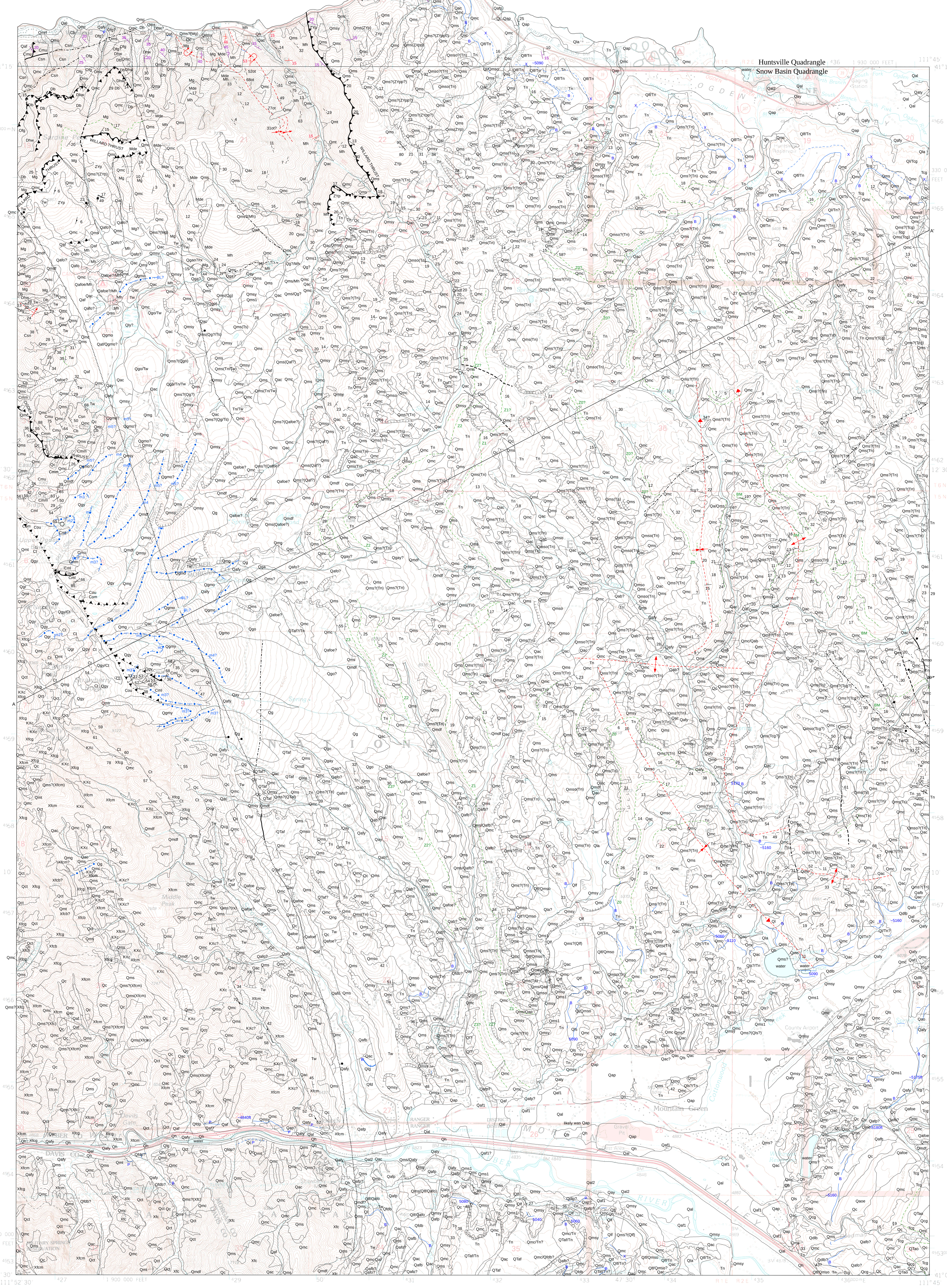
Sinkhole

Ql/Tn Thin Quaternary deposits underlain by other units (bedrock in this case)

Qms(Tn) Landslide with nearly intact rotated blocks of unit in parentheses; for example Qms(Tcg), Qms(Tn), Qms(Tw), Qms(Xfc); queried (Qms?, Qmso?) where blocks may be in place.

UTAH GEOLOGICAL SURVEY
a division of
Utah Department of Natural Resources

Utah Geological Survey Open-File Report 536
Interim Geologic Map of the Snow Basin and part of the Huntsville Quadrangle



SCALE 1:24,000

1 0.5 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 0.5 0 1 KILOMETER

CONTOUR INTERVAL 40 FEET

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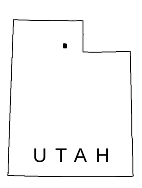
This geologic map was funded by the Utah Geological Survey and the U.S. Geological Survey, National Cooperative Geologic Mapping Program through U.S. Geological Survey STATEMAP award number 00HQAG109. The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Government



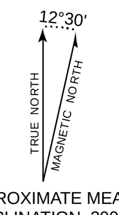
QUADRANGLE LOCATION

INTERIM GEOLOGIC MAP OF THE SNOW BASIN AND PART OF THE HUNTSVILLE QUADRANGLE, DAVIS, MORGAN, AND WEBER COUNTIES, UTAH

by

Jon K. King, W. Adolph Yonkee, and James C. Coogan

2008



APPROXIMATE MEAN DECLINATION, 2008

Base from USGS Snow Basin (1998) and Huntsville (1998) 7.5' Quadrangles
Projection: UTM Zone 12
Datum: NAD 1927
Spheroid: Clarke 1886

Project Manager: Doug Sprinkel
Cartography: Jon K. King and J. Buck Ehler

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1	2	3
4		5
6	7	8

1. North Ogden
2. Huntsville
3. Browns Hole
4. Ogden
5. Durst Mountain
6. Kaysville
7. Peterson
8. Morgan

ADJOINING 7.5' QUADRANGLE NAMES